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A Study of Brain Function Through Advanced Computer Techniques for Analysis of Electroencephalographic Data

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Substantial changes were made in the computing equipment supported under this grant in the Data Processing Laboratory of the Brain Research Institute. The CDC 160A computer was replaced by an SDS 920 computer as an interim step to the final acquisition of an SDS 930 computer in December, 1964. The SDS 930 computer is a powerful instrument, with a fast cycle time and a singular capability to accept many channels of physiological data at high speed in real time, and to process this data rapidly and efficiently.

In its present configuration, this computer has 12,000 words of 24 bit magnetic core memory, and its peripheral equipment includes two tape transports for intermediate storage and output. Input may be directly to a 20 channel analog-to-digital converter, integral with the computer, and having a maximum conversion rate of 20,000 per second. It may also be by punched cards or punched paper tape. Output is available on twin Calcomp plotters or on TEKTRONIX memory oscilloscopes. Considerable effort has gone into the development of a control console suitable for remote operation of the computer in adjacent laboratories. This control console can be used to initiate computing routines already stored in memory, or may be used by a sophisticated operator to actually construct a computing routine in the course of an experiment. It is anticipated that in the latter mode considerable advantages will be achieved in the development and testing of new computational procedures.

Plans are maturing for the direct interconnection of the SDS 930 computer with the IBM 7094 computer in the Health Science Computing Facility. An IBM 7094 computer has recently been installed in the Health Sciences Facility to develop this interface. When completed, analyses will proceed with on-line data transferred through digital formating in the SDS 930 to the IBM 7094 for computation, and a return of computer output to the investigator through the SDS 930 computer. This scheme of operation is conceived as having on-line capability for certain periods each day.

With this augmented computing capability, there has been a substantial increment in our capacity to analyze large amounts of data in sophisticated ways. Neurophysiological and psychophysiological data gathered on 200 pilot and astronaut candidates by Dr. Kellaway at the Houston Manned Spacecraft Center has proceeded much more rapidly than with the older system. Extended time series analyses, using auto - and cross spectral analyses has been a major commitment of the facility. These studies have revealed aspects of patterns relating to boredom and declining levels of attention. A variety of new computer output display techniques have been developed by Dr. D. O. Walter and Mr. Dan Brown to permit detailed display of relations between pairs of channels covering periods as long as twenty minutes.

This substantial degree of data compression is a vital requirement in the use of electroencephalographic techniques in monitoring pilot or astronaut performance in flight. Mathematical techniques used allow assessment of the levels of coherence, or linear predictability in relations between pairs of scalp leads. Auto- and cross-spectra of data so analyzed are displayed as a series of contour maps, which allow rapid visual interpretation by the investigator. Despite their highly compressed format, they retain all aspects of relevant detail over many minutes of analysis. In addition to contour maps, we have developed other techniques that display in serial fashion the linear and non-linear interrelations between different brain regions as these shift in subtle ways with changing levels of attention.

It is considered that these new methods transcend in validity any previous methods of assessment of physiological status of the central nervous system in monitoring alertness and performance capability.

Similar techniques are being applied to data gathered in baseline studies of the effects of centrifuging and vibration on electrical activity of the brains of monkeys in the Biosatellite Flight Experiment. This experiment, initiated by the Office of Space Sciences, involves one orbital monkey flight for a period of 30 days in the fall of 1966. Comprehensive analyses are being conducted of sleep and wakefulness cycles in anticipation of ways in which these may be altered in prolonged exposure to the space environment. Analyses are also being performed on this and data from human subjects on brief transient changes that occur in relation to focused attention and task performance.